

REMARKS

Claims 126–129, 133–134, 140–143, 159–170, 177–182, 188–197, 200, 204, 208–232, 234–235, 239, and 242–244 are pending.

Applicants note with appreciation that the Examiner has allowed claims 129, 133–134, 140–143, 159–170, 177–178, 181–182, 188–197, 200, 204, 208–232, 234–235, and 239.

Applicants also note with appreciation that the Examiner has indicated that claims 242–244 would be allowable if rewritten in independent form. Applicants have rewritten claims 242–244 in independent form.

Claim rejections under 35 U.S.C. §102

Claims 126–128, 179, and 180 are rejected under 35 U.S.C. §102(e) as directly anticipated by Chu et al., U.S. Patent No. 5,963,817 (“Chu”). Chu describes a method for forming buried oxide regions below a single-crystal semiconductor layer. Epitaxial layers with different oxidation rates are formed on a substrate, and a mask 24 of, e.g., silicon nitride (Si_3N_4) is defined over the epitaxial layers. Mask 24 may also be another material that is slow or resistant to oxidation or a material which is already an oxide. *See* abstract and column 2, lines 19–58.

Chu does not disclose a mask formed from a semiconductor material, as recited in independent claims 126, 128, and 179. Rather, Chu discloses a mask formed from a dielectric material. The exemplary Si_3N_4 mask disclosed by Chu does not include semiconducting atomic silicon. Rather, it includes a compound formed by the chemical bonding of silicon to nitrogen to define a dielectric material. This dielectric material is not a semiconductor material, nor does it include a semiconductor material, as recited in independent claims 126, 128, and 179. Moreover, Chu does not teach or suggest the inclusion of a semiconductor material in the dielectric silicon nitride mask 24.

As is known to one of skill in the art, silicon does not have the characteristics of a semiconductor material when it is combined with nitrogen, analogously to hydrogen no longer being flammable when combined with oxygen to form water. The fact that silicon nitride is a dielectric is also well known in the art. *See, e.g., S. Wolf et al., Silicon Processing for the VLSI*

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Era, Vol. 1: Process Technology, p. 191 (1986) (enclosed). Thus, silicon nitride is a dielectric compound formed by the chemical combination of silicon and nitrogen. As explained in *A Concise Dictionary of Chemistry*, Oxford Press, (1990) page 77, “[t]he formation of a compound involves a chemical reaction; i.e., there is a change in the configuration of the valence electrons of the atoms. Compounds, unlike mixtures, cannot be separated by physical means.” Thus, silicon nitride is formed by the chemical alteration of silicon starting material, whereby the silicon atoms are chemically altered by the sharing of valence electrons with nitrogen. After this chemical alteration, silicon nuclei cannot be separated from the nitrogen nuclei by physical means. Silicon nitride does not include silicon atoms with an electron configuration equivalent to that of elemental silicon.

Moreover, as is well known to one of skill in the art, the characteristics of a compound are different from that of the components from which it is formed:

A compound has unique properties that are distinct from the properties of its elemental constituents. One familiar chemical compound is water, a liquid that is nonflammable and does not support combustion. It is composed of two elements: hydrogen, an extremely flammable gas, and oxygen, a gas that supports combustion. A compound differs from a mixture in that the components of a mixture retain their own properties and may be present in many different proportions ... Another familiar compound is sodium chloride (common salt). It is composed of the silvery metal sodium and the greenish poisonous gas chlorine combined in the proportion of one atom of sodium to one atom of chlorine.

See <http://columbia.thefreedictionary.com/chemical+compound>. Similarly, silicon nitride is a dielectric material that is formed by a chemical reaction between a semiconductor and a gas. After this reaction, the “semiconductor” is no longer semiconducting and the “gas” is no longer a gas.

In summary, the mask 24 layer of Chu includes the dielectric compound silicon nitride. Chu does not teach or suggest an etch-stop layer including a semiconductor material as recited in independent claims 126, 128, and 179. Applicants submit that for at least this reason, independent claims 126, 128, and 179, and claims dependent therefrom, are patentable.

CONCLUSION

In light of the foregoing, Applicants respectfully submit that all claims are now in condition for allowance.

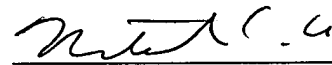
If the Examiner believes that a telephone conversation with Applicants' attorney would expedite allowance of this application, the Examiner is cordially invited to call the undersigned attorney at (617) 570-1806.

A check for \$600 for the extra claim fee is enclosed. Applicants believe that no additional fee is necessitated by the filing of this amendment. However, if any fee is due, please charge said fee occasioned by this paper to our Deposit Account No. 07-1700.

Respectfully submitted,

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SILICON PROCESSING FOR THE VLSI ERA

VOLUME 1:

PROCESS TECHNOLOGY

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source gases for B and P compete with one another for inclusion into the final deposited film. This makes for a complex relation of reactant gas composition to eventual film doping³⁶.

The chemical composition of BPSG (and PSG), can be determined by several techniques, including the following: a) *wet chemical colorimetry*, which is the most accurate, analyzes the dissolved BPSG film; b) *x-ray photoelectron spectroscopy* (see Chap. 17), which is useful for determining the phosphorus content of the film; c) *Fourier transform infrared spectroscopy* (see Chaps. 1 and 5) which can measure boron levels quite accurately, but phosphorus levels less well accurately (due to the presence of a partially obscured phosphorus-oxygen absorption band); and d) *film etch rates in buffered HF*. Since the etch rate of BPSG in buffered HF depends on the concentration of both B and P in the film, a determination of the etch rate can provide a rapid, qualitative comparison of the composition between BPSG samples.

PROPERTIES AND CHEMICAL VAPOR DEPOSITION OF SILICON NITRIDE

Silicon nitride films are amorphous insulating materials that find three main applications in VLSI fabrication: 1) as final passivation and mechanical protective layers for integrated circuits, especially for parts encapsulated in plastic packages; 2) as a mask for the selective oxidation of silicon; and 3) as a gate dielectric material in MNOS devices. Silicon nitride also has a high dielectric constant (6-9 vs ~4.2 for CVD SiO₂), making it less attractive for interlevel insulation, because of the resultant higher capacitance between conductor layers.

Silicon nitride is highly suitable as a *passivation layer* because of its following properties: a) it behaves as a nearly impervious barrier to diffusion (in particular, moisture and sodium find it very difficult to diffuse through the nitride film); b) it can be prepared by PECVD to have a low compressive stress, which allows it to be subjected to severe environmental stress with less likelihood of delamination or cracking; c) its coverage of underlying metal is conformal; and d) it is deposited with acceptably low pinhole densities.

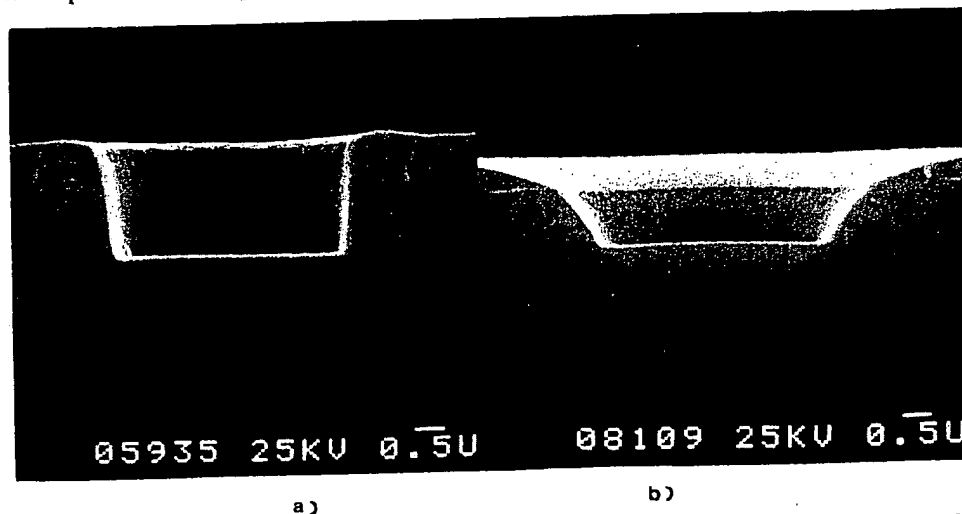
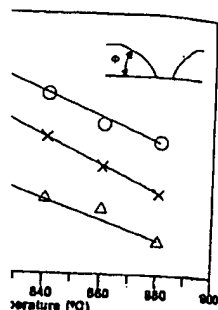


Fig. 24 (a) SEM of dry-etched contact window before reflow. (b) Reflowed BPSG film with 4 wt% P and 4 wt% B. Reflow was 930°C in N₂ for 25 min³⁷. Courtesy of Applied Materials, Inc.



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